A REFINEMENT OF OXYGEN ISOTOPIC COMPOSITION OF MARS. I.A. Franchi, A.S. Sexton, I.P. Wright and C.T. Pillinger, Planetary Sciences Research Institute, Open University, Walton Hall, Milton Keynes, MK7 6AA, UK

The variation in the oxygen stable isotopic compositions displayed by different groups of achondritic meteorites, the Earth, Moon and Mars is a function of isotopic heterogeneity in the solar nebula and subsequent post-accretional homogenisation of any original heterogeneities during the geologically active phase of the parent bodies. On a plot of d^{17}O vs. d^{18}O (oxygen three-isotope plot) homogenisation has the effect of reducing any isotopic variability to a single line with a slope of ≈0.52, since most geological processes affect the three isotopes of oxygen in a mass dependent manner. However, in the case of ureilites, acapulcoites and lodranites, although melting has clearly occurred, full isotopic homogenisation was not attained [1]. Herein, we are not concerned with these groups of unequilibrated achondrites. For the other groups of samples original nebular isotopic heterogeneities imparted inter-planet(esimal) variations which result in the different parent bodies defining different, but parallel lines on the oxygen three-isotope plot. The line defining the Earth is taken as areference and the offset from this line for any other body is expressed in terms of D^{17}O, as defined by Clayton and Mayeda [2]. Of particular importance is the difference in oxygen isotopic composition between planetary bodies, especially when it comes to recognising which samples derive from a particular body. Unfortunately the only body other than the Earth from which samples are available for study is Mars (the SNC meteorites). It seems appropriate to define the difference in oxygen isotopic composition between Earth and Mars to the best level of accuracy possible.

The oxygen isotopic compositions of all but one of the SNC meteorites have been reported previously [1,3], clearly discriminating them from terrestrial samples and also from the compositionally similar eucrites. The difference between the terrestrial fractionation line and that of the martian samples is small, apparently less than 0.3‰, but easily measurable, with replicates having a 1s standard deviation of about 0.07‰ [1]. However, in comparison to this small offset individual SNC meteorites do show considerable variation, their D^{17}O ranging from +0.16‰ to +0.38‰ with a mean value of 0.28‰ [1]. To investigate this variation further we have employed a laser fluorination technique which allows results of higher precision than has been possible previously.

The laser fluorination system is an upgraded version of that described before [4], with an all new ultra-high vacuum system, CO_2 laser (25W), beam delivery/view optics and a VG PRISM III mass spectrometer. We have also replaced ClF_3 with BrF_5 as the fluorinating reagent. Sample size requirements are about 1mg of silicate, although this can be readily taken to ≈0.2mg without any major loss of precision. The 1s standard deviation on d^{18}O from replicate analyses of standard materials is about ±0.06‰ and on D^{17}O ±0.015‰.

The recent high level of interest in ALH 84001 following the publication of McKay and others [5] perhaps in itself warrants a re-investigation of these meteorites. In particular, the very old crystallisation age of ALH 84001 [6], the oldest known sample from one of the terrestrial planets, may contain evidence of some large-scale isotopic heterogeneity from the solar nebula before it was fully homogenised by geological processes on the planet. Such evidence has been searched for in the past from old terrestrial samples but no heterogeneity has been found [7], one reason being the lack of any truly ancient terrestrial rocks.

We have performed replicate analyses on all the SNC meteorites with the exception of LEW88516 and Y793605, but including the previously unanalysed Governador Valadares. A summary of the results are shown in Table 1 and Figure 1. The d^{18}O values reported in Table 1 are similar to those reported by Clayton and Mayeda [1,3], although a number of meteorites show d^{18}O values that are higher by up to 0.5‰. From Figure 1 it is clear that the results from this study define a much more tightly constrained fractionation line, the best fit having a slope of 0.526. Within error the new data defines a line that is parallel to that for terrestrial rocks. The constancy of D^{17}O is best depicted in Figure 2, which shows that the meteorites define a mean value of +0.321±0.013‰ (±1s). The high precision of these results and the lack of any variation in $D^{17}O$ shows that there is little possibility for any doubt that these meteorites have a common, well homogenised source. That the $D^{17}O$ of ALH 84001 is indistinguishable from all the other SNC meteorites implies that any early internal martian heterogeneity could only have been very short-lived.

The mean value of $D^{17}O$ is almost 0.05‰ higher than that previously reported [1], however, as can be seen from Figure 2 there is good agreement with the previous results when three of the Antarctic meteorites are ignored. At face value the implication is that the samples analysed by Clayton and Mayeda [1,3] contain a proportion of terrestrial weathering products (martian weathering products can be discounted as these might be expected to have higher $D^{17}O$ values [8]). If so then the previous analyses of ALH A77005 [1] must have been performed on samples of which 50% of the oxygen analysed was terrestrial - this seems unlikely.

No acid washes were performed on the samples in this study - so why should the samples display no apparent weathering features? One possibility is that the laser fluorination technique, whereby multiple samples and standards are loaded in the same sample tray, is very efficient at removing any adsorbed terrestrial gases (*e.g.* water and O_2). Equally, phyllosilicate weathering products are also known to react to a certain extent with BrF_5 at room temperature. These too must have been eliminated. However, if the pre-fluorinations are repeated the amounts of oxygen generated after the initial treatment are very small, almost at baseline blank levels, indicating that there is no measurable cross contamination of samples. In conclusion the data reported here truly reflect the oxygen isotopic composition of the SNC meteorites. Furthermore, the isotopic variation of these meteorites is very small indeed, showing that the source is thoroughly homogenised. Assuming Mars is the parent body of the SNC meteorites then the $D^{17}O$ of this planet is +0.321±0.013‰.

References [1] R.N. Clayton and T.K. Mayeda (1996) GCA **60**, 1999-2017. [2] R.N. Clayton and T.K. Mayeda (1988) GCA **52**, 1313-1318. [3] R.N. Clayton and T.K. Mayeda (1983) EPSL **62**, 1-6. [4] .A. Franchi *et al* (1992) Meteoritics **27**, 222. [5] D.S. McKay *et al* (1996) Science **273**, 924-930. [6] E. Jagoutz *et al* (1994) Meteoritics **29**, 214. [7] F. Robert *et al* (1992) EPSL **108**, 1-9. [8] H.R. Karlson *et al* (1992) Science **255**, 1409-1411.

Table 1

Meteorite	**n**	**$d^{17}O$ ‰**	**$d^{18}O$ ‰**	**$D^{17}O$ ‰**
ALH A77005	3	2.64	4.45	0.326
EET A79001	3	2.60	4.38	0.321
QUE 94201	4	2.55	4.27	0.327
Shergotty	3	2.86	4.87	0.334
Zagami	2	2.99	5.09	0.343
Lafayette	3	2.85	4.88	0.310
Nakhla	2	3.02	5.22	0.305
Gov. Valdares	2	2.85	4.87	0.321
Chassigny	6	2.49	4.20	0.300
ALH 84001	4	2.74	4.64	0.327

Figure 1

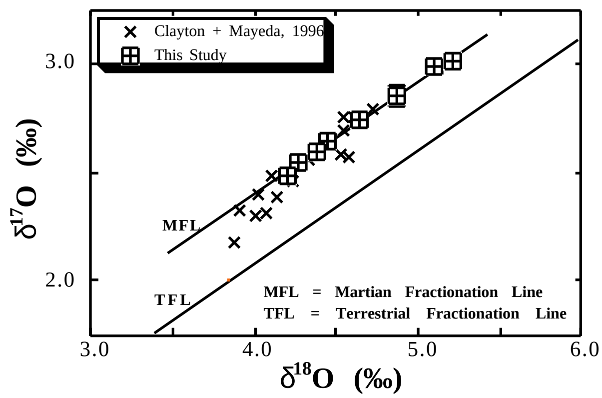

Figure 2